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CERTIFICATE

I, Kenichi KIKUCHI, residing at 2-10-18, Oyodo-naka, Kita-ku, Osaka, 531-0076, Japan, hereby certify that I am the translator of the attached document, namely a Certified Copy of Japanese Patent Application No. 10-096497 and certify that the following is a true translation to the best of my knowledge and belief.

Kenichi Kikuchi
Signature of Translator

April 6, 2004
Date

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[Name of Document]	Application for Patent
[Reference No.]	P0S62019
[Date of Filing]	April 08, 1998
[Addressee]	Commissioner of the Patent Office
[Int. Cl.]	G02F 1/133
[Title of the Invention]	LIQUID CRYSTAL DEVICE AND ELECTRONIC APPARATUS
[Total Number of Claims]	13
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[Application Fees]	
[Prepayment Registration No.]	013044
[Amount of Payment]	21000
[List of Documents Attached]	
[Name of Document]	Specification 1
[Name of Document]	Drawings 1
[Name of Document]	Abstract 1
[No. of General Power of Attorney]	9711684
[Proof]	Required

OIPE JC61
APR 20 2004
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[Name of Document] SPECIFICATION

[Title of the Invention] LIQUID CRYSTAL DEVICE AND ELECTRONIC DEVICE

[Claims]

[Claim 1] A liquid crystal device comprising a liquid crystal layer disposed between a first substrate and a second substrates; a first polarizer disposed on a side of the first substrate, opposite to a side in contact with the liquid crystal layer; reflective means formed on a side, in contact with the liquid crystal layer, of the second substrate; a second polarizer disposed on the side of the second substrate, opposite to the side in contact with the liquid crystal layer; and an illuminating apparatus disposed on a side of the second substrate, opposite to the side in contact with the second substrate,

wherein the reflective means has the capability of reflecting and passing light such that light incident from the side of the first polarizer is reflected toward the liquid crystal layer while light incident from the side of the second polarizer is passed through the reflective means into the liquid crystal layer, and a protective film and an electrode are formed on the reflective means.

[Claim 2] A liquid crystal device according to claim 1, wherein a plurality of small openings are formed in the surface of the reflective means.

[Claim 3] A liquid crystal device according to claim 1, wherein the reflective means includes aluminum and has a thickness in the range from 10 nm to 40 nm.

[Claim 4] A liquid crystal device according to claim 1, wherein a protective film and a color filter layer are formed on the reflective means formed on the second substrate.

[Claim 5] A liquid crystal device comprising a liquid crystal layer disposed between a first substrate and a second substrates; a first polarizer disposed on a side of the first substrate, opposite to a side in contact with the liquid crystal layer; reflective means formed on a side, in contact with the liquid crystal layer, of the second substrate; a second polarizer disposed on the side of the second substrate, opposite to the side in contact with the liquid crystal layer; and an illuminating apparatus disposed on a side of the second substrate, opposite to the side in contact with the second substrate,

wherein the reflective means formed on the second substrate includes a plurality of reflective parts separated from one another, and an electrode is formed on the reflective means such that a greater area than the area of each separated reflective part is covered with the electrode.

[Claim 6] A liquid crystal device comprising a liquid

crystal layer disposed between a first substrate and a second substrates; a first polarizer disposed on a side of the first substrate, opposite to a side in contact with the liquid crystal layer; reflective means formed on a side, in contact with the liquid crystal layer, of the second substrate; a second polarizer disposed on the side of the second substrate, opposite to the side in contact with the liquid crystal layer; and an illuminating apparatus disposed on a side of the second substrate, opposite to the side in contact with the second substrate, wherein the reflective means formed on the second substrate includes a plurality of reflective parts separated from one another, and an electrode is formed on the reflective means via a protective film such that a greater area than the area of each separated reflective part is covered with the electrode.

[Claim 7] A liquid crystal device according to claim 5 or 6, wherein a color filter layer is formed on the same side of the first substrate as the side in contact with the liquid crystal layer.

[Claim 8] A liquid crystal device according to one of claims 1 to 6, wherein the liquid crystal device is in a dark state when it is not driven.

[Claim 9] A liquid crystal device according to one of claims 1 to 8, wherein at least one first retardation film is disposed between the first substrate and the first

polarizer.

[Claim 10] A liquid crystal device according to one of claims 1 to 9, wherein at least one second retardation film is disposed between the second substrate and the second polarizer.

[Claim 11] A liquid crystal device according to one of claims 1 to 10, wherein a scattering layer is disposed on the surface of the first substrate, opposite to the surface in contact with the liquid crystal layer.

[Claim 12] A liquid crystal device according to one of claims 1 to 11, wherein the reflective surface is uneven.

[Claim 13] An electronic device including a liquid crystal device according to one of claims 1 to 12.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention]

The present invention relates to a liquid crystal device, and more particularly to the structure of a liquid crystal device capable of switching a display mode between a reflective display mode and a transmissive display mode, also to an electronic device using such a liquid crystal device.

[0002]

[Description of the Related Art]

Reflective liquid crystal devices can operate with very

small power consumption. Because of such an advantage, the reflective liquid crystal device is widely used as a display unit in portable devices and other various systems. However, an essential problem of the reflective liquid crystal device is that because an image is displayed using external light, it is difficult or impossible to see the image in a dark environment. To avoid the above problem, there has been proposed a liquid crystal device capable of switching the display mode depending on environment such that an image is displayed using external light in a light environment as with the conventional reflective type liquid crystal device, but an internal light source is used in a dark environment. A typical liquid crystal device of this type includes, as disclosed, for example, in Japanese Unexamined Patent Application Publication No. 57-049271, a polarizer, a transflector, and a backlight which are successively disposed on the outer surface, opposite to the viewing side, of a liquid crystal panel. In this liquid crystal device, an image is displayed in the reflective display mode when used in a light environment. In the reflective display mode, external light incident on the liquid crystal device is reflected by the transflector and an image is displayed using reflected light. On the other hand, when used in a dark environment, an image is displayed in the transmissive mode using light that is emitted by the

backlight and passed through the transflector.

[0003]

A transflective liquid crystal device with improved brightness is disclosed in Japanese Unexamined Patent Application Publication No. 8-292413. In this liquid crystal device, a transflector, a polarizer, and a backlight are successively disposed on the outer surface, opposite to the viewing side, of a liquid crystal panel. In this liquid crystal device, when used in a light environment, an image is displayed in the reflective display mode in which external light incident on the liquid crystal device is reflected by the transflector and the image is displayed using reflected light. On the other hand, when used in a dark environment, an image is displayed in the transmissive mode using light that is emitted by the backlight and passed through the transflector. Because there is no polarizer between the liquid crystal cell and the transflector, an image with improved brightness can be displayed.

[0004]

[Problems to be Solved by the Invention]

In the liquid crystal devices disclosed in Japanese Unexamined Patent Application Publications cited above, a transparent substrate disposed between a liquid crystal layer and a transflector can cause a ghost or blurring occurs in a displayed image.

[0005]

With recent advances in portable devices and office automation devices, there is an increasing need for color liquid crystal devices. In many cases, the capability of displaying a color image is also required in systems or devices using a reflective liquid crystal device. The capability of displaying a color image may be realized by combining a color filter and a liquid crystal device according to Japanese Unexamined Patent Application Publications cited above. However, in this case, a transflector is disposed at the back of a liquid crystal cell, and thus a thick transparent substrate of the liquid crystal cell is disposed between a transflector and a liquid crystal layer or a color filter, and the transparent substrate can cause a ghost or blurring to occur in a displayed image depending on the parallax. Thus, it is difficult to achieve good enough color display characteristics. To avoid the above problem, Japanese Unexamined Patent Publication No. 9-258219 discloses a reflective color liquid crystal device in which a reflector is disposed in contact with a liquid crystal layer. However, the problem of this reflective liquid crystal device is that because an image is displayed using external light, it is difficult or impossible to see the image in a dark environment.

[0006]

In view of the above, an object of the present invention is to provide a transflective color liquid crystal device capable of displaying an image without producing a ghost image or bleeding due to parallax. It is another object of the present invention to provide an electronic device using such a liquid crystal device.

[0007]

[Means for Solving the Problems]

The above objects are achieved by the present invention in various aspects described below.

[0008]

In an aspect, as described in claim 1, the present invention provides a liquid crystal device comprising a liquid crystal layer disposed between a first substrate and a second substrates; a first polarizer disposed on a side of the first substrate, opposite to a side in contact with the liquid crystal layer; reflective means formed on a side, in contact with the liquid crystal layer, of the second substrate; a second polarizer disposed on the side of the second substrate, opposite to the side in contact with the liquid crystal layer; and an illuminating apparatus disposed on a side of the second substrate, opposite to the side in contact with the second substrate, wherein the reflective means has the capability of reflecting and passing light

such that light incident from the side of the first polarizer is reflected toward the liquid crystal layer while light incident from the side of the second polarizer is passed through the reflective means into the liquid crystal layer, and a protective film and an electrode are formed on the reflective means.

[0009]

In this liquid crystal device, because the second substrate is not located between the reflective means and the liquid crystal layer, a ghost or bleeding does not occur when an image is displayed in the reflective display mode. When this liquid crystal device is used in a sufficiently light environment, an image is displayed in the reflective color display mode in which external light is reflected by the reflective means. On the other hand, when the intensity of external light is not high enough, an image is displayed in the transmissive color display mode in which light emitted by the backlight is passed through the second polarizer and polarized light is further passed through the color filter layer and the liquid crystal layer. In many cases, the voltage vs. reflectance (transmittance) characteristic of the liquid crystal cell is different between the reflective display mode and the transmissive display mode. Therefore, it is desirable that the driving voltage is changed depending on whether an image is

displayed in the reflective display mode or the transmissive display mode so that the image is displayed in an optimized manner.

[0010]

In general, the reflective means is formed using a metal material chiefly containing aluminum. However, aluminum is very poor in resistance to chemical agents and is very difficult to deal with. Furthermore, aluminum is easily damaged. To avoid the above problem, in the present embodiment, the surface of the reflective layer formed of aluminum or the like is covered with the protective film, and, on this protective film, other layers including the color filter layer, another protective film, and the transparent electrode are formed. Therefore, aluminum is prevented from direct contact with a chemical agent. This makes it possible to easily deal with aluminum without damaging it.

[0011]

The protective film may be formed using a transparent material such as an acryl resin or silicon oxide. The protective film between the color filter layer and the transparent electrode is not necessarily needed. For example, in a case in which the present invention is applied to a substrate opposite to a substrate on which active elements are formed in a TFT active matrix liquid crystal

device. In this case, patterning of the transparent electrode on the opposite substrate is not necessary, and thus the protective film between the color filter layer and the transparent electrode is not necessary.

[0012]

In a liquid crystal device according to an aspect, as described in claim 2, a plurality of small openings are formed in the surface of the reflective means.

[0013]

In the liquid crystal device according to this aspect, when the liquid crystal device is used in a sufficiently light environment, an image is displayed in the reflective color display mode in which external light incident on the liquid crystal device is reflected by the reflective means and the image is displayed using reflected light. On the other hand, when the intensity of external light is not high enough, the backlight is turned on and an image is displayed in the transmissive color display mode. More specifically, light emitted by the backlight is passed through the second polarizer, and linearly polarized light is passed through the small openings formed in the reflective layer serving as the reflective means into the liquid crystal layer. The openings can be easily formed by means of a patterning process using a resist, including coating, exposing, developing, and removing the resist.

[0014]

It is desirable that the diameter of each opening be within the range from 0.01 μm and 20 μm, so that the openings are not easily perceived by users and thus degradation in image quality due to the openings is negligible, thereby allowing a high-quality image to be displayed in both reflective and transmissive modes.

[0015]

It is also desirable that the ratio of the total area of the openings to the total area of the reflective means be within the range from 5% to 30% so that the reduction in the brightness is minimized in the reflective display mode whereas an image is also allowed to be displayed in the transmissive mode using light supplied via the openings formed in the reflective means.

[0016]

In a liquid crystal device according to an aspect, as described in claim 3, the reflective means includes 95 percent by weight or more aluminum and has a thickness in the range from 10 nm to 40 nm.

[0017]

In this aspect, the reflective means is in the transflective form with a small thickness. Experiments have turned out that it is possible to produce, according to the present aspect, a transflector having a thickness within the

above-described range and having a transmittance in the range from 1% to 40% and a reflectance in the range of 50% to 95%.

[0018]

In a liquid crystal device according to an aspect, as described in claim 4, a protective film and a color filter layer are formed on the reflective means formed on the second substrate.

[0019]

In an aspect, as described in claim 5, the present invention provides a liquid crystal apparatus comprising a liquid crystal layer disposed between a first substrate and a second substrates; a first polarizer disposed on a side of the first substrate, opposite to a side in contact with the liquid crystal layer; reflective means formed on a side, in contact with the liquid crystal layer, of the second substrate; a second polarizer disposed on the side of the second substrate, opposite to the side in contact with the liquid crystal layer; and an illuminating apparatus disposed on a side of the second substrate, opposite to the side in contact with the second substrate, wherein the reflective means formed on the second substrate includes a plurality of reflective parts separated from one another, and an electrode is formed on the reflective means such that a greater area than the area of each separated reflective part

is covered with the electrode.

[0020]

In this liquid crystal device, because the second substrate is not located between the reflective means and the liquid crystal layer, a ghost or bleeding does not occur when an image is displayed in the reflective display mode. When this liquid crystal device is used in a sufficiently light environment, displaying in the reflective display mode is performed by reflecting external light incident on the liquid crystal device by the plurality of separated reflective parts of the reflective means (hereinafter, referred to simply as separated reflective parts). On the other hand, when the intensity of external light is not high enough, an image is displayed in the transmissive display mode in which light emitted by the backlight is passed through the second polarizer and polarized light is brought into the liquid crystal layer through spaces between adjacent separated reflective parts, that is, through regions in which no reflective means is formed. Because the transparent electrode is formed such that its area is greater than the separated reflective part, light passing through the transparent electrode extending outward from the edge of each separated reflective part is modulated, and thus displaying in the transmissive display mode is achieved. Light passing through spaces between adjacent

transparent electrodes results in a reduction in contrast in the transmissive display mode. To avoid the above problem, it is desirable to form a light blocking layer on the surface, facing the liquid crystal layer, of the first substrate so that light is blocked by the light blocking layer.

[0021]

In many cases, the voltage vs. reflectance (transmittance) characteristic of the liquid crystal cell is different between the reflective display mode and the transmissive display mode. Therefore, it is desirable that the driving voltage is changed depending on whether an image is displayed in the reflective display mode or the transmissive display mode so that the image is displayed in an optimized manner.

[0022]

In an aspect, as described in claim 6, the present invention provides a liquid crystal device comprising a liquid crystal layer disposed between a first substrate and a second substrates; a first polarizer disposed on a side of the first substrate, opposite to a side in contact with the liquid crystal layer; reflective means formed on a side, in contact with the liquid crystal layer, of the second substrate; a second polarizer disposed on the side of the second substrate, opposite to the side in contact with the

liquid crystal layer; and an illuminating apparatus disposed on a side of the second substrate, opposite to the side in contact with the second substrate, wherein the reflective means formed on the second substrate includes a plurality of reflective parts separated from one another, and an electrode is formed on the reflective means via a protective film such that a greater area than the area of each separated reflective part is covered with the electrode.

[0023]

In this liquid crystal device, because the second substrate is not located between the reflective means and the liquid crystal layer, a ghost or bleeding does not occur when an image is displayed in the reflective display mode. When this liquid crystal device is used in a sufficiently light environment, an image is displayed in the reflective display mode in which external light is reflected by the separated reflective part. On the other hand, when the intensity of external light is not high enough, an image is displayed in the transmissive display mode in which light emitted by the backlight is passed through the second polarizer and polarized light is brought into the liquid crystal layer through spaces between adjacent separated reflective parts, that is, through regions in which no reflective means is formed. Because the transparent electrode is formed such that its area is greater than the

separated reflective part, light passing through the transparent electrode extending outward from the edge of each separated reflective part is modulated, and thus displaying in the transmissive display mode is achieved. In general, the separated reflective part is formed using a metal material chiefly containing aluminum. However, aluminum is very poor in resistance to chemical agents and is very difficult to deal with. Furthermore, aluminum is easily damaged. To avoid the above problem, in the present embodiment, the surface of the reflective layer formed of aluminum or the like is covered with the protective film, and the transparent electrode is formed on the protective film. Therefore, aluminum is prevented from direct contact with a chemical agent. This makes it possible to easily deal with aluminum without damaging it. Light passing through spaces between adjacent transparent electrodes results in a reduction in contrast in the transmissive display mode. To avoid the above problem, it is desirable to form a light blocking layer on the surface, facing the liquid crystal layer, of the first substrate so that light is blocked by the light blocking layer.

[0024]

In many cases, the voltage vs. reflectance (transmittance) characteristic of the liquid crystal cell is different between the reflective display mode and the

transmissive display mode. Therefore, it is desirable that the driving voltage is changed depending on whether an image is displayed in the reflective display mode or the transmissive display mode so that the image is displayed in an optimized manner.

[0025]

The protective film may be formed using a transparent material such as an acryl resin or silicon oxide.

[0026]

In a liquid crystal device in an aspect, as described in claim 7, a color filter layer is formed on the same side of the first substrate as the side in contact with the liquid crystal layer.

[0027]

This aspect according to the present invention makes it possible to display a color image in the reflective display mode or transmissive display mode.

[0028]

It is desirable that the color filter layer have a transmittance greater than 25% over the wavelength range from 380 nm to 780 nm so that a color image with a high brightness can be displayed in the reflective display mode and the transmissive display mode.

[0029]

In a liquid crystal device in an aspect, as described

in claim 8, the liquid crystal device is in a dark state (black state) when it is not driven.

[0030]

In the liquid crystal device in this aspect, because the liquid crystal is in the dark (black) state (non-transmissive state) when the liquid crystal is not driven, undesirable transmission of light through spaces between undriven pixels or dots is prevented, and thus high contrast is achieved in the transmissive display mode.

[0031]

In a liquid crystal device in an aspect, as described in claim 9, at least one first retardation film is disposed between the first substrate and the first polarizer.

[0032]

In the liquid crystal device in this aspect, degradation in a color tone due to wavelength dispersion of light is minimized and a high-quality image can be displayed in both the transmissive display mode and the reflective display mode.

[0033]

In a liquid crystal device in an aspect, as described in claim 10, at least one second retardation film is disposed between the second substrate and the second polarizer.

[0034]

In the liquid crystal device in this aspect, degradation in a color tone due to wavelength dispersion of light is minimized and a high-quality image can be displayed in the transmissive display mode.

[0035]

In a liquid crystal device in an aspect, as described in claim 11, a scattering layer is disposed on the surface of the first substrate, opposite to the surface in contact with the liquid crystal layer.

[0036]

In the liquid crystal device in this aspect, the scattering layer allows the surface of the reflective layer or the separated reflective parts to act as a scattering surface (white surface). The scattering layer may be disposed at any location as long as it is on the side opposite to the side in contact with the liquid crystal layer. However, if the back scattering effect (the effect of scattering incident external light toward the side from which light is incident) of the scattering layer is taken into account, it is desirable to dispose the scattering layer between the polarizer and the first substrate. Such back scattering does not make any contribution to displaying an image but causes a reduction in the contrast in the reflective display mode. If the scattering layer is disposed between the polarizer and the first substrate, the

amount of back-scattered light is reduced by approximately one-half.

[0037]

In a liquid crystal device in an aspect, as described in claim 12, the reflective surface is uneven.

[0038]

In the liquid crystal device in this aspect, the uneven surface of the reflective layer or the separated reflective parts allows the surface to act as a scattering surface (white surface). Furthermore, the uneven surface causes light to be reflected randomly thereby allowing a displayed image to be viewed from a wide angle. The uneven surface may be formed by disposing a photosensitive acryl resin as an underlayer of the reflective layer or by roughening, using hydrofluoric acid, the surface of a glass substrate itself serving as the underlayer.

[0039]

In an aspect, as described in claim 13, the present invention provides an electronic device having a liquid crystal device according to one of aspects descried above.

[0040]

This aspect of the invention makes it possible to realize an electronic device using a transflective liquid crystal device capable of switching the display mode between the reflective display mode and the transmissive display

mode in either one of which a high-quality image having no ghost and no bleeding due to parallax can be displayed.

[0041]

[Description of the Embodiments]

Embodiments of the present invention are described below with reference to the accompanying drawings.

[0042]

(First Embodiment)

Fig. 1 is a longitudinal sectional view schematically illustrating the structure of a liquid crystal device according to a first embodiment of the present invention. Although this embodiment is basically concerned with a passive matrix type liquid crystal device, the structure disclosed herein may also be applied to other types of liquid crystal devices such as an active matrix type device, a segment type device, etc.

[0043]

In this embodiment, there is provided a liquid crystal cell including a liquid crystal layer 103 sealed between two transparent substrates 101 and 102 and within a frame-shaped sealing member 104. The liquid crystal layer 103 is formed of a nematic liquid crystal with a particular twisted angle. A plurality of stripe-shaped transparent electrodes 109 are formed of ITO or the like on the inner surface of the upper transparent substrate 101. An alignment layer 110 is formed

over the surface of the transparent electrodes 109 and subjected to a rubbing process in a predetermined direction.

[0044]

On the other hand, on the inner surface of the lower transparent substrate 102, a transflector 111, a protective film 112 formed of SiO_2 or the like, and a color filter 114 are formed one on another. The color filter 114 includes three colored layers of R (red), G (green), and B (blue) with predetermined patterns. The surface of the color filter 114 is coated with a transparent protective film 115. A plurality of stripe-shaped transparent electrodes 116 are formed of an ITO film or the like on the surface of this protective film 115 such that they cross the transparent electrodes 109 for the respective colored layers of the color filter 114. In the case of an active matrix type device including MIMs or TFTs, each transparent electrode 116 is formed in a rectangular shape and connected with an interconnection via an active device. The reflective layer 111 is formed of Cr, Al, or the like, and the surface thereof serves as a reflection plane for reflecting light incident from the side of the transparent substrate 101. An alignment layer 117 is formed over the transparent electrodes 116. Openings with a diameter of 2 μm are formed in the transflector 111, wherein the openings are formed at random locations such that the total area of openings

becomes approximately equal to 10% of the total area of the transflector.

[0045]

A polarizer 105 is disposed on the outer surface of the upper transparent substrate 101, and a retardation film 106 is disposed between the polarizer 105 and the transparent substrate 101. On the lower side of the liquid crystal cell, a retardation film 108 is disposed at the back of the transparent substrate 102, and a polarizer 107 is disposed at the back of the retardation film 108. Furthermore, on the lower side of the polarizer 107, there is disposed a backlight including a fluorescent tube 119 for emitting white light and a light guiding plate 118 having a light incident end face extending along the fluorescent tube 119. The light guiding plate 118 is formed of a transparent material such as acrylic resin in such a manner that its entire back surface becomes rough so as to serve as a diffusing surface. Light emitted from the fluorescent tube 119 serving as a light source is input into the light guiding plate 118 through its end face, and light is output substantially uniformly through the upper surface. Other types of backlights such as an LED (light emitting diode) or an EL (electroluminescence) lamp may also be employed.

[0046]

In the present embodiment, to prevent light from

leaking through areas between adjacent dots in the transmissive display mode, a black matrix layer 113 serving as a light shielding member is formed in a horizontal plane at locations corresponding to the spaces between adjacent colored areas of the color filter 114. The black matrix layer 113 may be formed by coating a Cr layer or may be formed of a photosensitive black resin.

[0047]

In the reflective display mode, external light incident from the upper side in Fig. 1 onto the liquid crystal device passes through the polarizer 105, the retardation film 106, and the liquid crystal layer 103. The light further passes through the color filter 114 and is then reflected by the transflector 111. The reflected light is output to the outside via the polarizer 105. In this reflective display mode, the intensity of output light is controlled to a bright, dark, or intermediate level in response to the voltage applied to the liquid crystal layer 103.

[0048]

In the case where an image is displayed in the transmissive display mode, light emitted from the backlight is converted by the polarizer 107 and the retardation film 108 into light with predetermined polarization and is brought into the liquid crystal layer 103 via openings of the transflector 111. After that, the light passes through

the color filter 114, the liquid crystal layer 103, and the retardation film 106. In this transmissive display mode, the light transmission is controlled by the voltage applied across the liquid crystal layer 103 into a state where the light passes through the polarizer 105 (bright state) or a state where the light is absorbed by the polarizer 105 (dark state) or otherwise into an intermediate state (with intermediate brightness).

[0049]

By employing the structure disclosed herein in the present embodiment, it is possible to realize a color liquid crystal device capable of switching the display mode between the reflective and transmissive modes in any of which an image can be displayed without producing a ghost image or bleeding.

[0050]

In the present embodiment, the transflector 111 is formed of an Al metal layer in which an opening is formed. The surface of the transflector 111 is covered with a protective film, and, on this protective film, other layers including the color filter layer, another protective film, and the transparent electrode are formed. Therefore, the Al metal layer is prevented from coming into direct contact with the developing solutions used to form the ITO film and the color filter and thus the Al metal layer is prevented

from being dissolved into the developing solutions. Furthermore, the Al metal layer, which tends to be easily damaged, can be handled without damaging it.

[0051]

(Second Embodiment)

Fig. 4 is a longitudinal sectional view schematically illustrating the structure of a liquid crystal device according to a second embodiment of the present invention. Although this embodiment is basically concerned with a passive matrix type liquid crystal device, the structure disclosed herein may also be applied to other types of liquid crystal devices such as an active matrix type device, a segment type device, etc.

[0052]

In the present embodiment, there is provided a liquid crystal cell including a liquid crystal layer 403 sealed between two transparent substrates 401 and 402 and within a frame-shaped sealing member 404. The liquid crystal layer 403 is formed of a nematic liquid crystal with negative dielectric anisotropy. A plurality of stripe-shaped transparent electrodes 409 are formed of ITO or the like on the inner surface of the upper transparent substrate 401. An alignment layer 410 for aligning the liquid crystal in vertical direction is formed over the transparent electrodes 409 and rubbed in a predetermined direction. The rubbing is

performed so that liquid crystal molecules have a pretilt angle of about 85° to the rubbing direction. In the case of an active matrix type device including MIMs or TFTs, each transparent electrode 409 is formed in a rectangular shape and connected with an interconnection via an active device.

[0053]

On the other hand, a corrugation with a top-to-bottom height of about 0.8 μm is formed of a photosensitive acrylic resin on the inner surface of the lower transparent substrate 402. Aluminum added with 1.0 percent by weight Nd is sputtered to a thickness of 25 nm onto the surface of the acrylic resign thereby forming a reflective layer 411. A color filter 414 is formed over the transflector 411 via a protective film 412. The color filter 414 includes three colored layers of R, G, and B with predetermined patterns. The surface of the color filter 414 is coated with a transparent protective film. A plurality of stripe-shaped transparent electrodes 416 are formed of ITO or the like on the surface of the protective film such that they cross the transparent electrodes 409 for the respective colored layers of the color filter 414. An alignment layer 417 similar to that in the previous embodiment is formed over the transparent electrodes 416. This alignment layer 417 is not subjected to the rubbing process.

[0054]

A polarizer 405 is disposed on the outer surface of the upper transparent substrate 401, and a retardation film (quarter-wave film) 406 is disposed between the polarizer 405 and the transparent substrate 401. On the lower side of the liquid crystal cell, a retardation film (quarter-wave film) 408 is disposed at the back of the transparent substrate 402, and a polarizer 407 is disposed at the back of the retardation film (quarter-wave film) 408. Furthermore, on the lower side of the polarizer 407, there is disposed a backlight including a fluorescent tube 419 for emitting white light and a light guiding plate 418 having a light incident end face extending along the fluorescent tube 419. The light guiding plate 418 is formed of a transparent material such as acrylic resin in such a manner that its entire back surface becomes rough so as to serve as a diffusing surface. Light emitted from the fluorescent tube 419 serving as a light source is input into the light guiding plate 418 through its end face, and light is output substantially uniformly through the upper surface. Other types of backlights such as an LED (light emitting diode) or an EL (electroluminescence) lamp may also be employed.

[0055]

In the present embodiment, to prevent light from leaking through areas between adjacent dots in the transmissive display mode, a black matrix layer 413 serving

as a light shielding member is formed in a horizontal plane at locations corresponding to the spaces between adjacent colored areas of the color filter 414. The black matrix layer 413 may be formed by coating a Cr layer or may be formed of a photosensitive black resin.

[0056]

Herein, as shown in Fig. 7(a), the polarizers 405 and 407 are disposed such that their polarization axes P1 and P2 extend in the same direction. The retardation films (quarter-wave films) 406 and 408 are disposed such that their delayed phase axes C1 and C2 extend in a direction rotated by = 45° in a clockwise direction relative to the polarization axes P1 and P2 of the polarizers 405 and 407. The alignment layer 410 on the inner surface of the transparent substrate 401 is subjected to a rubbing process in the same direction as the delayed phase axes C1 and C2 of the retardation films (quarter-wave films) 406 and 408. The rubbing direction R1 determines the direction in which long axes of liquid crystal molecules are tilted when an electric filed is applied across the liquid crystal layer 403. A negative nematic liquid crystal is employed to form the liquid crystal layer 403. Fig. 7(b) is a graph illustrating the reflectance R and the transmittance T as a function of the driving voltage obtained when the liquid crystal device according to the present embodiment is used in the

reflective display mode. Herein, the liquid crystal device is in a dark (black) state when no electric field is applied. When this liquid crystal cell is used, there is no need to form the black matrix layer 413.

[0057]

In the reflective display mode, external light incident from the upper side in Fig. 4 onto the liquid crystal device passes through the polarizer 405, the retardation film 406, and the liquid crystal layer 403. The light further passes through the color filter 414 and is then reflected by the transflector 411. The reflected light is output to the outside via the polarizer 405. In this reflective display mode, the image brightness can be controlled by the voltage applied across the liquid crystal layer 403 into a bright, dark, or intermediate state.

[0058]

In the case where an image is displayed in the transmissive display mode, light emitted from the backlight is converted by the polarizer 407 and the retardation film 408 into light with predetermined polarization and is brought into the liquid crystal layer 403 via the transflector 411. After that, the light passes through the color filter 414, the liquid crystal layer 403, and the retardation film 406. In this transmissive display mode, the light transmission is controlled according to the

voltage applied across the liquid crystal layer 403 into a state where the light passes through the polarizer 405 (bright state) or a state where the light is absorbed by the polarizer 405 (dark state) or otherwise into an intermediate state (with intermediate brightness).

[0059]

By employing the structure according to the present embodiment described herein, it is possible to realize a color liquid crystal device capable of switching the display mode between the reflective and transmissive modes in any of which an image can be displayed without producing a ghost image or bleeding.

[0060]

In the present embodiment, the reflective layer 411 is formed of a metal layer chiefly containing Al. The surface of the reflective layer 411 is covered with the protective film. Furthermore, a color filter, a protective film, and a transparent electrode are formed on the projective film 411. Therefore, the Al metal layer is prevented from coming into direct contact with developing solutions used to form the ITO film and the color filter and thus the Al metal layer is prevented from being dissolved into the developing solutions. Furthermore, the Al metal layer can be handled without damaging it. For example, a 25 nm thick Al metal layer added with 1.0 percent by weight Nd has a reflectance

of 80% and a transmittance of 10%, and thus it provides good characteristics when used to form the transflector 411.

[0061]

Furthermore, the transflector 411 having an uneven surface can reflect light over a wide range of angles, and thus it is possible to achieve a liquid crystal device having a wide viewing angle.

[0062]

(Third Embodiment)

Fig. 2 is a longitudinal sectional view schematically illustrating the structure of a liquid crystal device according to a third embodiment of the present invention. Although this embodiment is basically concerned with a passive matrix type liquid crystal device, the structure disclosed herein may also be applied to other types of liquid crystal devices such as an active matrix type device, a segment type device, etc.

[0063]

In this embodiment, there is provided a liquid crystal cell including a liquid crystal layer 203 sealed between two transparent substrates 201 and 202 and within a frame-shaped sealing member 204. The liquid crystal layer 203 is formed of a nematic liquid crystal with a particular twisted angle. A color filter 213 is formed on the inner surface of the upper transparent substrate 201. The color filter 213

includes three colored layers of R (red), G (green), and B (blue) with predetermined patterns. The surface of the color filter is coated with a transparent protective film 212. A plurality of stripe-shaped transparent electrodes 211 are formed of ITO or the like on the surface of this protective film 212. An alignment layer 210 is formed over the surface of the transparent electrodes 211 and subjected to a rubbing process in a predetermined direction.

[0064]

On the inner surface of the lower transparent substrate 202, stripe-shaped transparent electrodes 215 slightly greater in area than the reflective layer 216 are formed on the stripe-shaped reflective layer 216 formed at locations corresponding to the respective colored layers of the color filter 213 described above, in such a manner that the transparent electrodes 215 cross the transparent electrodes 211. In the case of an active matrix type device including MIMs or TFTs, the reflective layer 216 and the transparent electrode 215 are formed in rectangular shapes and connected with interconnections via active devices. The reflective layer 216 is formed of Cr, Al, or the like, and the surface thereof serves as a reflection plane for reflecting light incident from the side of the transparent substrate 201. An alignment layer 214 is formed over the transparent electrodes 215.

[0065]

A polarizer 205 is disposed on the outer surface of the upper transparent substrate 201, and a retardation film 206 and a scattering layer 207 are disposed between the polarizer 205 and the transparent substrate 201. On the lower side of the liquid crystal cell, a retardation film 209 is disposed at the back of the transparent substrate 202, and a polarizer 208 is disposed at the back of the retardation film 209. Furthermore, on the lower side of the polarizer 208, there is disposed a backlight including a fluorescent tube 218 for emitting white light and a light guiding plate 217 having a light incident end face extending along the fluorescent tube 218. The light guiding plate 217 is formed of a transparent material such as acrylic resin in such a manner that its entire back surface becomes rough so as to serve as a diffusing surface. Light emitted from the fluorescent tube 218 serving as a light source is input into the light guiding plate 217 through its end face, and light is output substantially uniformly through the upper surface. Other types of backlights such as an LED (light emitting diode) or an EL (electroluminescence) lamp may also be employed.

[0066]

In the reflective display mode, external light incident from the upper side in Fig. 2 onto the liquid crystal device

passes through the polarizer 205, the retardation film 206, and the scattering layer 207. The light further passes through the color filter 213 and the liquid crystal layer 203 and is then reflected by the reflective layer 216 serving as reflection means. The reflected light is output to the outside via the polarizer 205. In this reflective display mode, the intensity of output light is controlled to a bright, dark, or intermediate level in response to the voltage applied to the liquid crystal layer 203.

[0067]

In the case where an image is displayed in the transmissive display mode, light emitted from the backlight is converted by the polarizer 208 and the retardation film 209 into light with predetermined polarization and brought into the liquid crystal layer 203 and the color filter 213 via spaces where no reflective layer 216 is formed. After that, the light passes through the scattering layer 207 and the retardation film 206. In this transmissive display mode, the light transmission is controlled by the voltage applied across the liquid crystal layer 203 into a state where the light passes through the polarizer 205 (bright state) or a state where the light is absorbed by the polarizer 205 (dark state) or otherwise into an intermediate state (with intermediate brightness).

[0068]

The operation of displaying an image is described in further detail below for both the reflective display mode and the transmissive display mode with reference to Figs. 5 and 6. Fig. 5 is a front view schematically illustrating a lower transparent substrate 202 used in an active matrix type liquid crystal device including MIMs, according to the present invention. In Fig. 5, reference numeral 501 denotes a scanning line, 502 denotes an MIM device (or a TFD device), 503 denotes an Al reflective layer, and 504 denotes an ITO transparent electrode having a slightly greater area than the Al reflective layer. Fig. 6 is a front view schematically illustrating a passive matrix type liquid crystal device according to the present invention. In Fig. 6, reference numeral 601 denotes an ITO transparent electrode on the inner surface of an upper transparent substrate of a liquid crystal cell, 602 denotes an Al reflective layer on the inner surface of a lower transparent substrate, and 603 denotes an ITO transparent electrode having a slightly greater area than the Al reflective layer. In the reflective display mode, external light input into the liquid crystal cell is reflected by the reflective layer 503 or 602. That is, of the external light, only the part which is incident on the reflective layer 503 or 602 is modulated according to the voltage applied across the liquid crystal layer. In the transmissive display mode, of light

input from the backlight into the liquid crystal cell, only the part which passes through the reflective layer 503 or 602 is brought into the liquid crystal layer. However, light incident upon areas other than the pixel electrodes or the dot electrodes does not make any contribution to displaying an image but causes a reduction in the contrast in the transmissive display mode. To avoid this problem, such light is blocked by providing a light shielding film (black matrix layer) or by displaying the image in a normal black fashion. That is, in the transmissive display mode, an image is displayed by light input from the backlight through the areas where there are only ITO transparent electrode 504 or 603 but there in no overlapping Al reflective layer 503 or 602. Although in the present embodiment, the Al reflective layer is in the form of lines, there is no particular restriction on the form of the Al reflective layer.

[0069]

For example, if the ITO transparent electrodes 601 formed on the inner surface of the upper transparent substrate shown in Fig. 6 each have a line width (L) of 198 μm, the Al reflective layers 602 formed on the inner surface of the lower substrate each have a line width (W1) of 46 μm, and the ITO transparent electrodes 603 formed over the Al reflective layers 602 each have a line width (W2) of 56 μm,

then approximately 70% of external light brought into the liquid crystal layer is reflected, and approximately 10% of light input from the backlight into the lower transparent substrate is passed.

[0070]

By employing the structure disclosed herein in the present embodiment, it is possible to realize a color liquid crystal device capable of switching the display mode between the reflective and transmissive modes in any of which an image can be displayed without producing a ghost image or bleeding.

[0071]

Because the Al reflective layer 216 is covered with the ITO transparent electrode 215, the Al reflective layer 216 is prevented from being damaged. Furthermore, because both the Al reflective layer and the ITO transparent electrode 215 contribute to electric conduction of electrode lines, a reduction in resistance is achieved for each electrode line.

[0072]

Furthermore, the scattering layer 207 disposed on the upper surface of the liquid crystal cell serves to output light reflected by the Al reflective layer 216 such that the light is diffused over a wide range of angles. This makes it possible to realize a liquid crystal device with a wide viewing angle.

[0073]

(Fourth Embodiment)

Fig. 3 is a longitudinal sectional view schematically illustrating the structure of a liquid crystal device according to a fourth embodiment of the present invention. Although this embodiment is basically concerned with a passive matrix type liquid crystal device, the structure disclosed herein may also be applied to other types of liquid crystal devices such as an active matrix type device, a segment type device, etc.

[0074]

In this embodiment, as in the previous embodiments, there is provided a liquid crystal cell including a liquid crystal layer 303 sealed between two transparent substrates 301 and 302 and within a frame-shaped sealing member 304. The liquid crystal layer 303 is formed of a nematic liquid crystal with a particular twisted angle. A color filter 313 is formed on the inner surface of the upper transparent substrate 301. The color filter 313 includes three colored layers of R (red), G (green), and B (blue) with predetermined patterns. The surface of the color filter is coated with a transparent protective film 312. A plurality of stripe-shaped transparent electrodes 311 are formed of ITO or the like on the surface of this protective film 312. An alignment layer 310 is formed over the surface of the

transparent electrodes 311 and subjected to a rubbing process in a predetermined direction.

[0075]

On the inner surface of the lower transparent substrate 302, stripe-shaped transparent electrodes 315 slightly greater in area than the reflective layer 317 are formed, via a protective film 316, on the stripe-shaped reflective layer 317 formed at locations corresponding to the respective colored layers of the color filter 313 described above, wherein a plurality of such transparent electrodes 315 are disposed such that they cross the transparent electrodes 311. In the case of an active matrix type device including MIMs or TFTs, the reflective layer 317 and the transparent electrode 315 are formed in rectangular shapes and connected with interconnections via active devices. The reflective layer 317 is formed of Cr, Al, or the like, and the surface thereof serves as a reflection plane for reflecting light incident from the side of the transparent substrate 301. An alignment layer 314 is formed over the transparent electrodes 315.

[0076]

A polarizer 305 is disposed on the outer surface of the upper transparent substrate 301, and a retardation film 306 and a scattering layer 307 are disposed between the polarizer 305 and the transparent substrate 301. On the

lower side of the liquid crystal cell, a retardation film 309 is disposed at the back of the transparent substrate 302, and a polarizer 308 is disposed at the back of the retardation film 309. Furthermore, on the lower side of the polarizer 308, there is disposed a backlight including a fluorescent tube 319 for emitting white light and a light guiding plate 318 having a light incident end face extending along the fluorescent tube 319. The light guiding plate 318 is formed of a transparent material such as acrylic resin in such a manner that its entire back surface becomes rough such as to serve as a diffusing surface. Light emitted from the fluorescent tube 319 serving as a light source is input into the light guiding plate 318 through its end face, and light is output substantially uniformly through the upper surface. Other types of backlights such as an LED (light emitting diode) or an EL (electroluminescence) lamp may also be employed.

[0077]

In the reflective display mode, external light passes through the polarizer 305, the retardation film 306, and the scattering layer 307 shown in Fig. 3. The light further passes through the color filter 313 and the liquid crystal layer 303 and is then reflected by the reflective layer 317. The reflected light is output to the outside via the polarizer 305. In this reflective display mode, the image

brightness can be controlled by the voltage applied across the liquid crystal layer 303 into a bright, dark, or intermediate state.

[0078]

In the case where an image is displayed in the transmissive display mode, light emitted from the backlight is converted by the polarizer 308 and the retardation film 309 into light with predetermined polarization and brought into the liquid crystal layer 303 and the color filter 313 via spaces where no reflective layer 317 is formed. After that, the light passes through the scattering layer 307 and the retardation film 306. In this transmissive display mode, the light transmission is controlled by the voltage applied across the liquid crystal layer 303 into a state where the light passes through the polarizer 305 (bright state) or a state where the light is absorbed by the polarizer 305 (dark state) or otherwise into an intermediate state (with intermediate brightness).

[0079]

The operation of displaying an image is described in further detail below for both the reflective display mode and the transmissive display mode with reference to Figs. 5 and 6. Fig. 5 is a front view schematically illustrating a lower transparent substrate 202 used in an active matrix type liquid crystal device including MIMs, according to the

present invention. In Fig. 5, reference numeral 501 denotes a scanning line, 502 denotes an MIM device (or a TFD device), 503 denotes an Al reflective layer, and 504 denotes an ITO transparent electrode having a slightly greater area than the Al reflective layer. Fig. 6 is a front view schematically illustrating a passive matrix type liquid crystal device according to the present invention. In Fig. 6, reference numeral 601 denotes an ITO transparent electrode on the inner surface of an upper transparent substrate of a liquid crystal cell, 602 denotes an Al reflective layer on the inner surface of a lower transparent substrate, and reference numeral 603 denotes an ITO transparent electrode formed on the Al reflective layer via a protective film, wherein the ITO transparent electrode 603 has a slightly greater area than the Al reflective layer.

In the reflective display mode, external light input into the liquid crystal cell is reflected by the reflective layer 503 or 602. That is, of the external light, only the part which is incident on the reflective layer 503 or 602 is modulated according to the voltage applied across the liquid crystal layer. In the transmissive display mode, of light input from the backlight into the liquid crystal cell, only the part which passes through the reflective layer 503 or 602 is brought into the liquid crystal layer. However, light incident upon areas other than the pixel electrodes or

the dot electrodes does not make any contribution to displaying an image but causes a reduction in the contrast in the transmissive display mode. To avoid this problem, such light is blocked by providing a light shielding film (black matrix layer) or by displaying the image in a normal black fashion. That is, in the transmissive display mode, an image is displayed by light input from the backlight through the areas where there are only ITO transparent electrode 504 or 603 but there in no overlapping Al reflective layer 503 or 602. Although in the present embodiment, the Al reflective layer is in the form of lines, there is no particular restriction on the form of the Al reflective layer.

[0080]

For example, if the ITO transparent electrodes 601 formed on the inner surface of the upper transparent substrate shown in Fig. 6 each have a line width (L) of 240 μm, the Al reflective layers 602 formed on the inner surface of the lower substrate each have a line width (W1) of 60 μm, and the ITO transparent electrodes 603 formed over the Al reflective layers 602 each have a line width (W2) of 70 μm, then approximately 75% of external light brought into the liquid crystal layer is reflected, and approximately 8% of light input from the backlight into the lower transparent substrate is passed.

[0081]

By employing the structure disclosed herein in the present embodiment, it is possible to realize a color liquid crystal device capable of switching the display mode between the reflective and transmissive modes in any of which an image can be displayed without producing a ghost image or bleeding.

[0082]

In the present embodiment, after forming the protective film over the Al reflective layer, the ITO transparent electrode 315 is formed on the protective film. Therefore, the Al reflective layer is prevented from direct contact with a developing solution or an etchant used to form the ITO transparent electrode. Furthermore, the protective film prevents the Al reflective layer from being damaged. By electrically connecting the Al reflective layer with the ITO transparent electrode, it becomes possible to reduce the probability that electric disconnection occurs, and it also becomes possible to reduce the resistance of the electrode lines.

[0083]

Furthermore, the scattering layer 307 disposed on the upper surface of the liquid crystal cell serves to output light reflected by the Al reflective layer 317 such that the light is diffused over a wide range of angles. This makes

it possible to realize a liquid crystal device with a wide viewing angle.

[0084]

(Fifth Embodiment)

Fig. 8 is a longitudinal sectional view schematically illustrating the structure of a liquid crystal device according to a fifth embodiment of the present invention. Although this embodiment is basically concerned with a passive matrix type liquid crystal device, the structure disclosed herein may also be applied to other types of liquid crystal devices such as an active matrix type device, a segment type device, etc. The structure shown in Fig. 8 is similar to that shown in Fig. 3 except for the structure of the reflective layer 817.

[0085]

The reflective layer 817 is formed as follows. A photosensitive resist is coated on the inner surface of the transparent substrate 802 using a spin coating technique or the like. The photosensitive resist is then exposed to light with controlled intensity through a mask having small openings. After that, the photosensitive resist is baked as required and then developed so that portions corresponding to the openings of the mask are removed thereby forming a supporting layer having a corrugated shape in cross section. In the above photolithography process, the portions of the

photosensitive resist corresponding to the openings of the mask may be removed or left without being removed, and the uneven surface geometry may be smoothed by means of etching or heating thereby achieving a corrugated shape in cross section. An additional layer may be formed on the surface of the supporting layer so as to obtain a smoother surface.

[0086]

A thin film of metal is then deposited on the surface of the supporting layer by means of evaporation or sputtering thereby forming a metal film having a reflection plane. The thin film is then patterned into the shape of stripes. The metals which can be employed here include Al, Cr, Ag, and Au. Because the corrugated shape of the surface of the supporting layer is reflected in the formation of the reflective layer 817, the reflective layer 817 has a generally rough surface.

[0087]

In the reflective display mode, external light incident from the upper side in Fig. 8 onto the liquid crystal device passes through the polarizer 805, the retardation film 806, the color filter 813, and the liquid crystal layer 803. The light is then reflected by the reflective layer 817 and emitted to the outside via the polarizer 805. In this reflective display mode, the image brightness can be controlled by the voltage applied across the liquid crystal

layer 803 into a bright, dark, or intermediate state.

[0088]

In the case where an image is displayed in the transmissive display mode, light emitted from the backlight is converted by the polarizer 808 and the retardation film 809 into light with predetermined polarization and brought into the liquid crystal layer 303 and the color filter 813 via spaces where no reflective layer 817 is formed. After that, the light passes through the retardation layer 206. In this transmissive display mode, the light transmission is controlled by the voltage applied across the liquid crystal layer 803 into a state where the light passes through the polarizer 805 (bright state) or a state where the light is absorbed by the polarizer 805 (dark state) or otherwise into an intermediate state (with intermediate brightness).

[0089]

By employing the structure disclosed herein in the present embodiment, it is possible to realize a color liquid crystal device capable of switching the display mode between the reflective and transmissive modes in any of which an image can be displayed without producing a ghost image or bleeding.

[0090]

In the present embodiment, after forming the protective film over the Al reflective layer, the ITO transparent

electrode 315 is formed on the protective film. Therefore, the Al reflective layer is prevented from direct contact with a developing solution or an etchant used to form the ITO transparent electrode. Furthermore, the protective film prevents the Al reflective layer from being damaged. By electrically connecting the Al reflective layer with the ITO transparent electrode, it becomes possible to reduce the probability that electric disconnection occurs, and it also becomes possible to reduce the resistance of the electrode lines.

[0091]

Furthermore, the reflective layer 817 having an uneven surface can reflect light over a wide range of angles, and thus it is possible to achieve a liquid crystal device having a wide viewing angle.

[0092]

Referring now to Fig. 13, the colored layers of the color filter 213, 313, or 414 used in the first to eighth embodiments are described below. In any embodiment, when an image is displayed in the reflective display mode, incident light passes through one of colored layers of the color filter and further passes through the liquid crystal layer. The light is then reflected by the reflective layer and passes again through one of the colored layers. After that, the light is output to the outside. Thus, as opposed to

usual reflective liquid crystal devices, light passes twice through the color filter. Therefore, if a usual type color filter is employed, the brightness and the contrast of an image displayed become low. In each embodiment, to avoid such a problem, the color filter is formed to have lightly colored layers of R, G, and B each having transmittance in the visible wavelength range greater than a minimum value set to 25 to 50%. The lightly colored layers may be obtained by reducing the thickness of each colored layer or by reducing the concentration of pigments or dyes contained in the respective colored layers. The employment of the lightly colored layers makes it possible to display an image in the reflective display mode without causing a reduction in the brightness.

[0093]

The employment of the color filter having lightly colored layers causes the displayed image to have lighter colors in the transmissive display mode because light passes only once through the color filter in the transmissive display mode. This is desirable in that a brighter image can be obtained, because in any embodiment a large amount of light emitted from the backlight is blocked by the reflective layer.

[0094]

(Sixth Embodiment)

Three examples of electronic devices in an aspect, described claim 12, of the present invention are described below.

[0095]

The liquid crystal device according to the present invention is suitable for use in a portable device that is used in various environments and that needs low power consumption.

[0096]

Fig. 9(a) shows a portable telephone having a display disposed in an upper area on the upper surface of its main body. Portable telephones are used indoors and outdoors under various conditions. In particular, portable telephones are often used in cars. When a portable telephone is used in a car at nighttime, the inside of the car is very dark. Therefore, for use as the display unit in the portable telephone, it is desirable to employ a transflective liquid crystal device capable of displaying an image in the reflective display mode with low power consumption in most cases and also capable of displaying an image in the transmissive display mode using auxiliary light as required. The liquid crystal device according to the present invention is advantageous in that an image with a higher brightness and a higher contrast can be displayed in both the reflective and transmissive displaying mode than

can be by a conventional liquid crystal device.

[0097]

Fig. 9(b) illustrates a watch including a display unit disposed in the center of the main body. An important item required for watches is a high-class appearance. In this liquid crystal device, not only a high brightness and a high contrast are achieved but also coloring is minimized because variations in characteristics depending on the wavelength of light are small. Thus, it is possible to realize a watch with a color display unit having an extremely high-class appearance compared to conventional watches.

[0098]

Fig. 9(c) illustrates a portable information device including a display unit disposed on the upper side of the main body and an input unit disposed on the bottom side. In most cases, a touch key is provided on the front surface of the display unit. In general, the touch key is difficult to see because of large surface reflection. To reduce such a difficulty, a transmissive liquid crystal device is employed in many cases as the display unit even in portable type devices. However, the transmissive liquid crystal device consumes large electric power because the backlight is always used. Therefore, the battery life is short. Also in this case, a liquid crystal device according to the present invention can be advantageously employed as the display unit

of the portable information device thereby ensuring that a bright and clear image is displayed in any display mode, reflective, transflective, or transmissive mode.

[0099]

[Advantages]

As descried above, the liquid crystal device according to the present invention has the advantage that a high-quality image is displayed without producing a ghost or bleeding, and the display mode is switched depending on an environmental condition such that an image is displayed in the reflective color display mode in which the image is displayed using external light reflected by the reflective means, while the backlight is lit when the intensity of external light is not high enough.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a longitudinal sectional view schematically illustrating the structure of a liquid crystal device according to a first embodiment of the present invention.

[Fig. 2]

Fig. 2 is a longitudinal sectional view schematically illustrating the structure of a liquid crystal device according to a third embodiment of the present invention.

[Fig. 3]

Fig. 3 is a longitudinal sectional view schematically

illustrating the structure of a liquid crystal device according to a fourth embodiment of the present invention.

[Fig. 4]

Fig. 4 is a longitudinal sectional view schematically illustrating the structure of a liquid crystal device according to a second embodiment of the present invention.

[Fig. 5]

Fig. 5 is a front view schematically illustrating a lower transparent substrate 202 used in an active matrix type liquid crystal device including MIMs, according to the present invention.

[Fig. 6]

Fig. 6 is a front view schematically illustrating an example of a passive matrix type liquid crystal device according to the present invention.

[Fig. 7]

Fig. 7(a) is a schematic diagram illustrating the relationship in terms of rubbing directions among a polarizer, a retardation film and a liquid crystal according to the second embodiment, and Fig. 7(b) is a graph illustrating the reflectance/transmittance vs. driving voltage characteristic of the liquid crystal device under the conditions shown in Fig. 7(a).

[Fig. 8]

Fig. 8 is a longitudinal sectional view schematically

illustrating the structure of a liquid crystal device according to a fifth embodiment of the present invention.

[Fig. 9]

Fig. 9 is a schematic diagram showing electronic devices using a liquid crystal device according to the present invention.

[Reference Numerals]

101, 102, 201, 202, 301, 302, 401, 402, 801, 802: transparent substrate

103, 203, 303, 403, 803: liquid crystal layer

104, 204, 304, 404, 804: sealing material

105, 107, 205, 208, 305, 308, 405, 407, 805, 808: polarizer

106, 108, 206, 209, 306, 309, 406, 408, 806, 809: retardation film

109, 116, 211, 215, 311, 315, 409, 416, 504, 811, 815: transparent electrode

110, 117, 210, 214, 310, 314, 410, 417, 810, 814: alignment layer

111, 411: transflector

112, 115, 212, 312, 316, 412, 415, 812, 816: protective film

113, 413: black matrix (light blocking film)

114, 213, 313, 414, 813: color filter

118, 217, 318, 418, 818: light guiding plate

119, 218, 319, 419, 819: fluorescent tube

207, 307: scattering layer

216, 317, 503, 602, 817: reflective layer

501: scanning line

502: MIM or TFD

601: transparent electrode formed on the inner surface of the upper substrate

603: transparent electrode formed on the inner surface of the lower substrate

[Name of Document] ABSTRACT

[Abstract]

[Object] An object is to provide a transflective color liquid crystal device capable of displaying an image in a reflective display mode or a transmissive display mode selected depending on an environmental condition without producing a ghost image or bleeding due to parallax.

[Solving Means] In a dark environment, a backlight is lit. White light emitted from the backlight is brought into a polarizer 107 through the surface of a light guiding plate 118. The light is further passed through a retardation film 108 and brought into a liquid crystal cell. The light is then brought into a liquid crystal layer 103 via a transflector 111 and a color filter 114. The light is then brought, from the liquid crystal cell, into a retardation film 106 and further into a polarizer 105 and then is emitted to the outside. In a light environment, external light incident on the polarizer 105 is passed through the liquid crystal layer 103 and is reflected by the transflector 111. The reflect light is again passed through the polarizer 105 and emitted to the outside.

[Selected Figure] Fig. 1

OIPE JC61
APR. 2 0 2004
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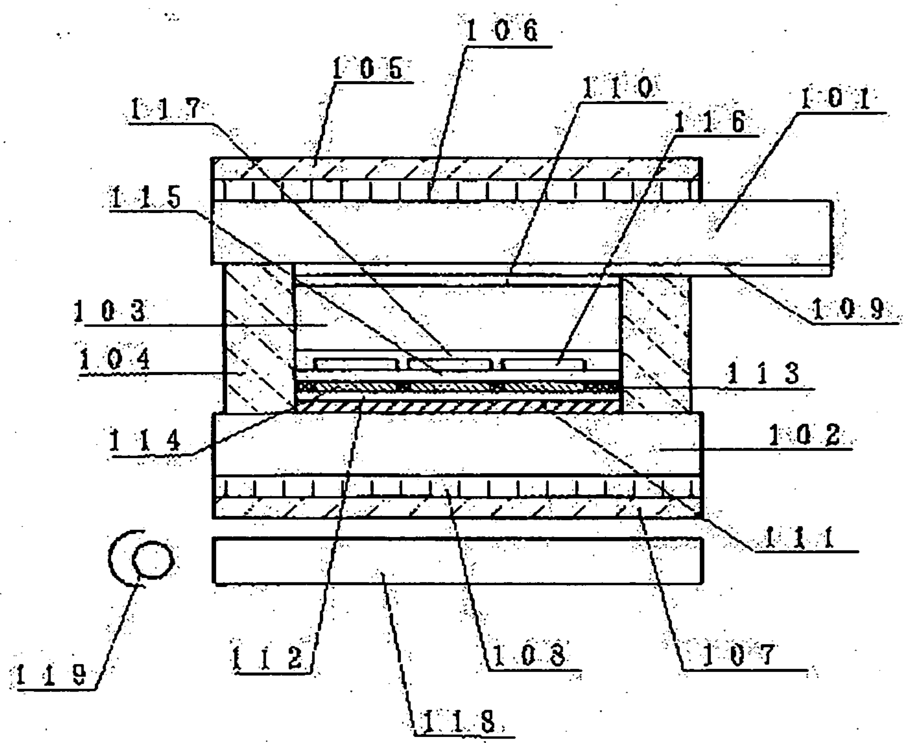
【Name of Document】 Drawings

【FIG. 1】



OIPE JC61
APR 2 0 2004
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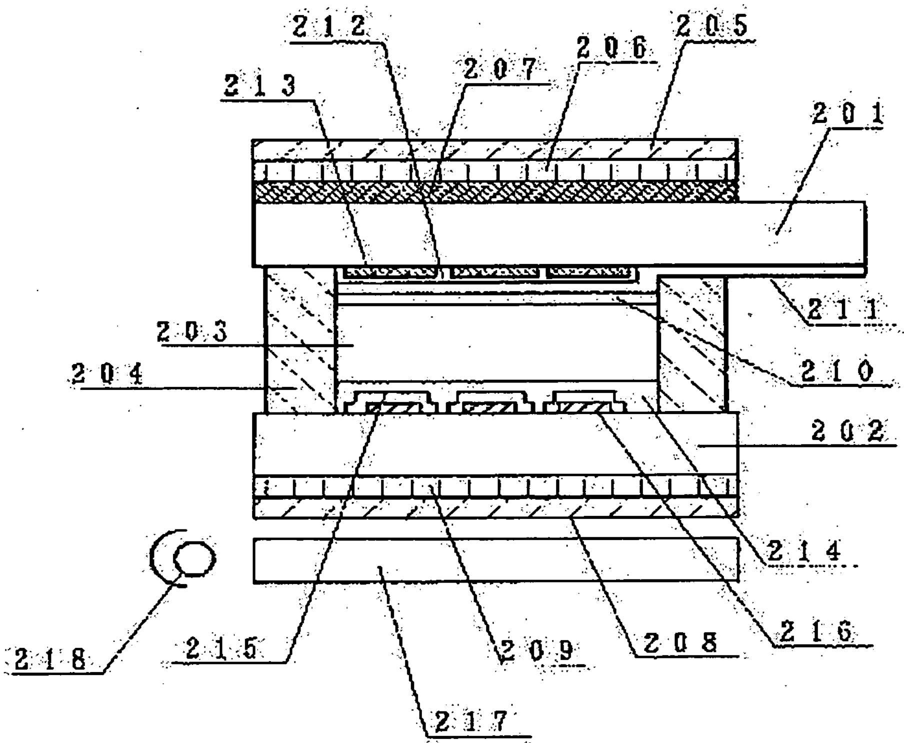
【FIG. 2】



OIPE JC81
APR 2 0 2004
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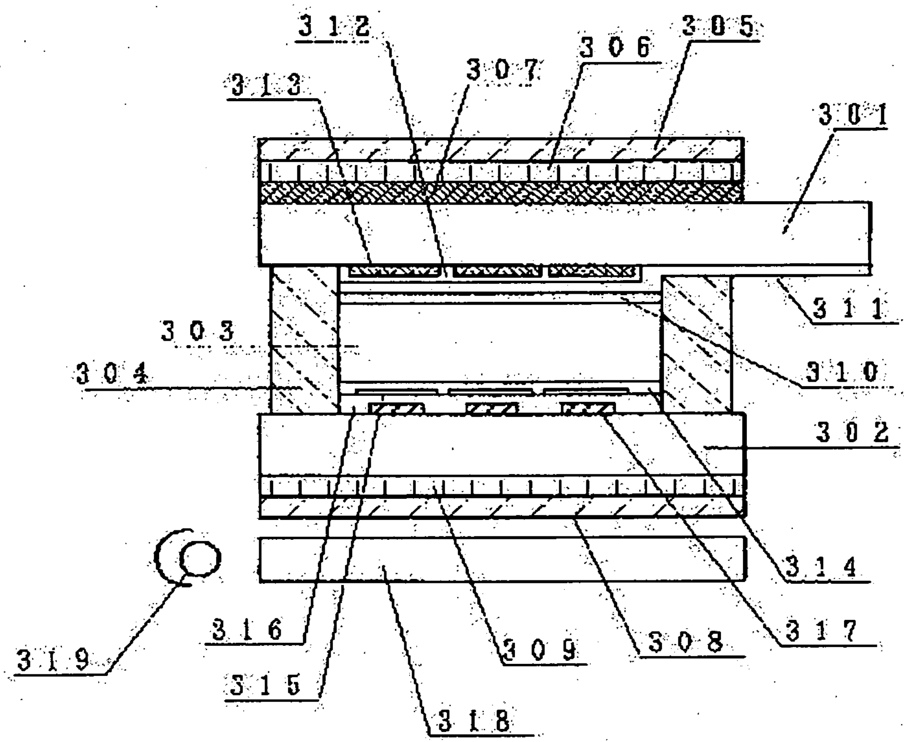
【FIG. 3】



OIPE JC61
APR 2 0 2004
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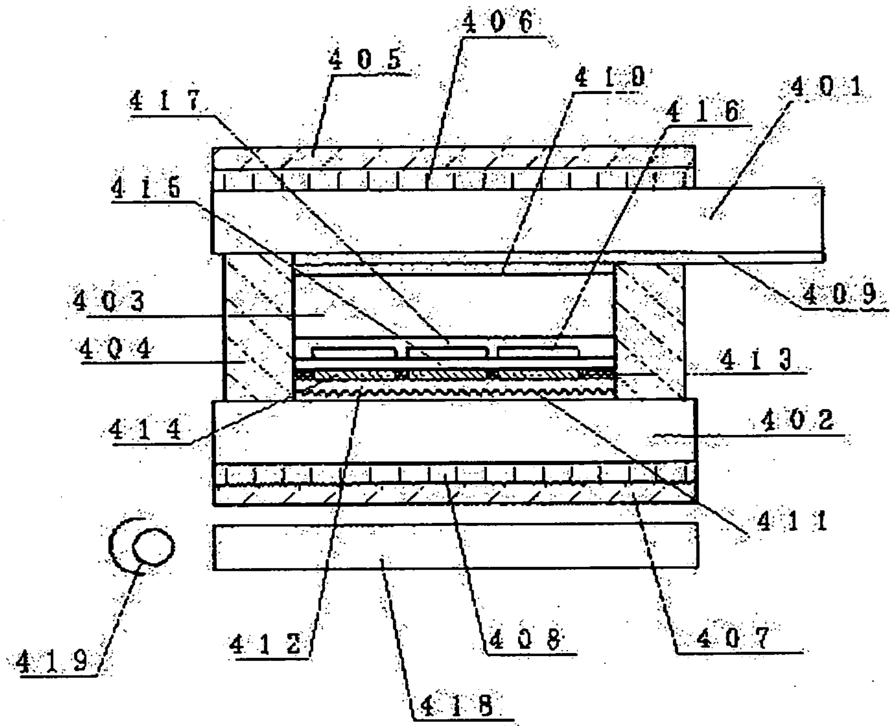
【FIG. 4】



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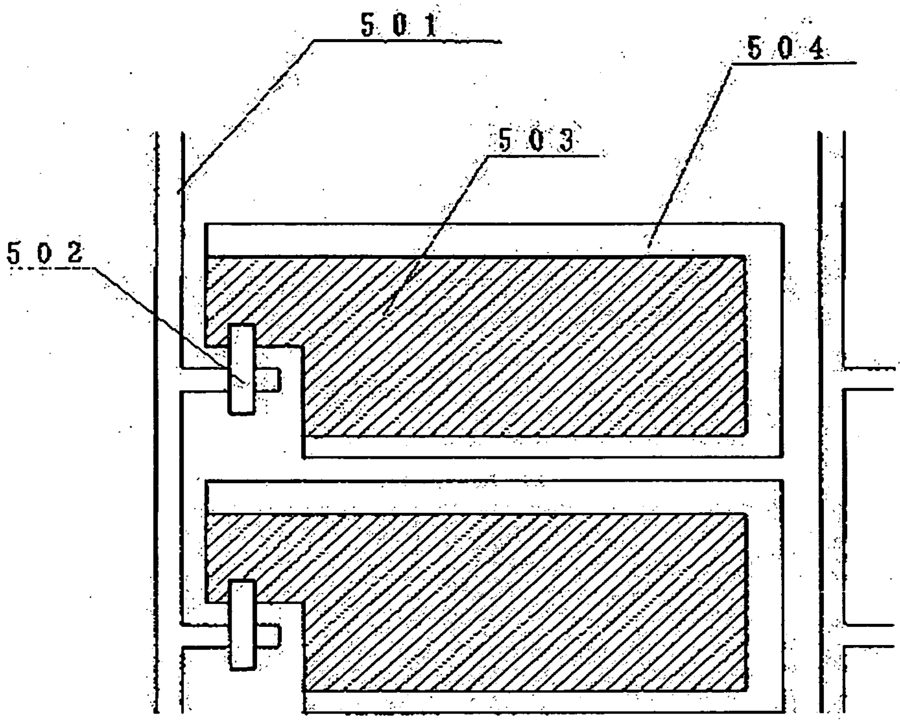
【FIG. 5】



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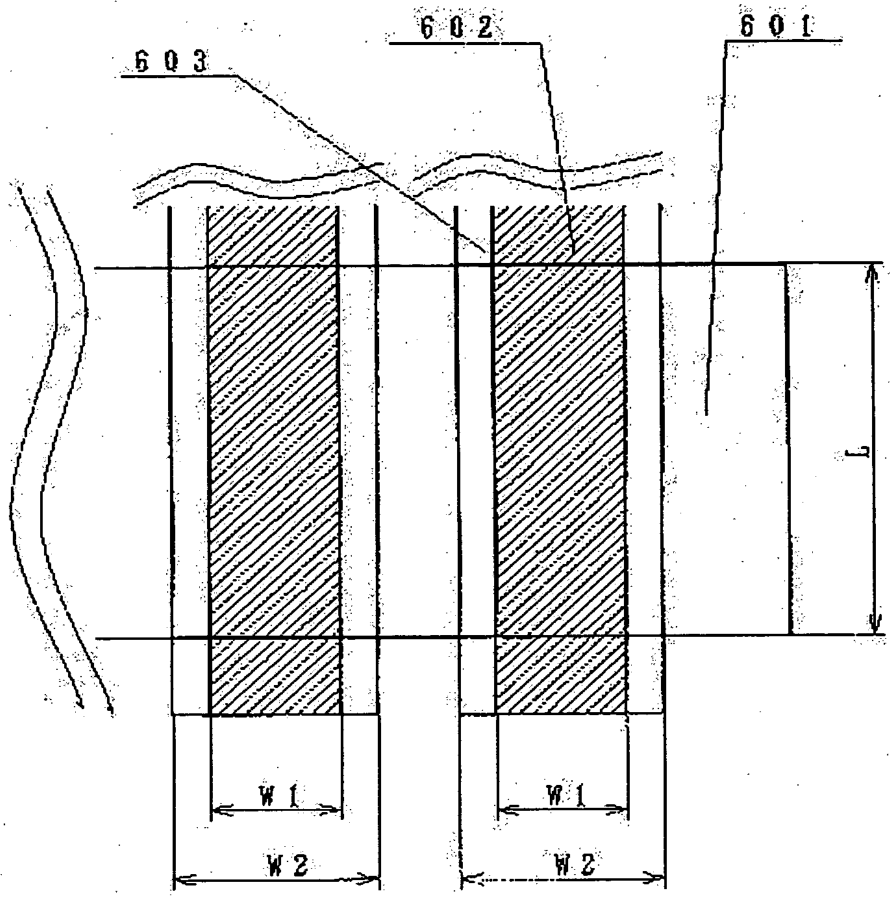
【FIG. 6】



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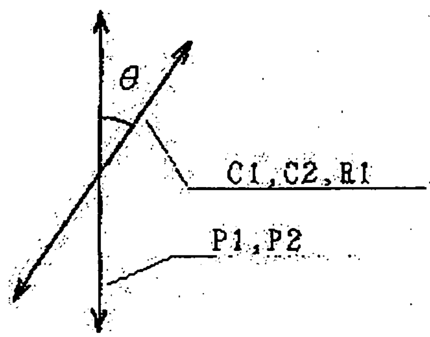
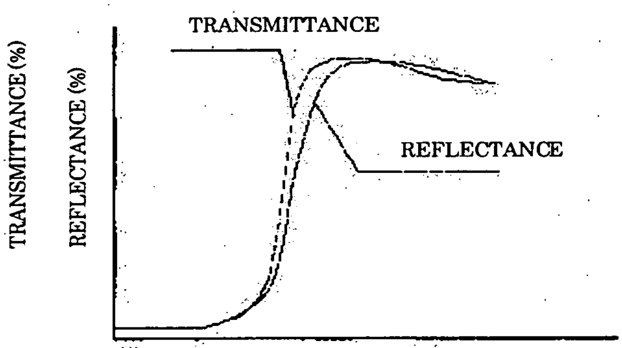
【FIG. 7】



(a)



(b)

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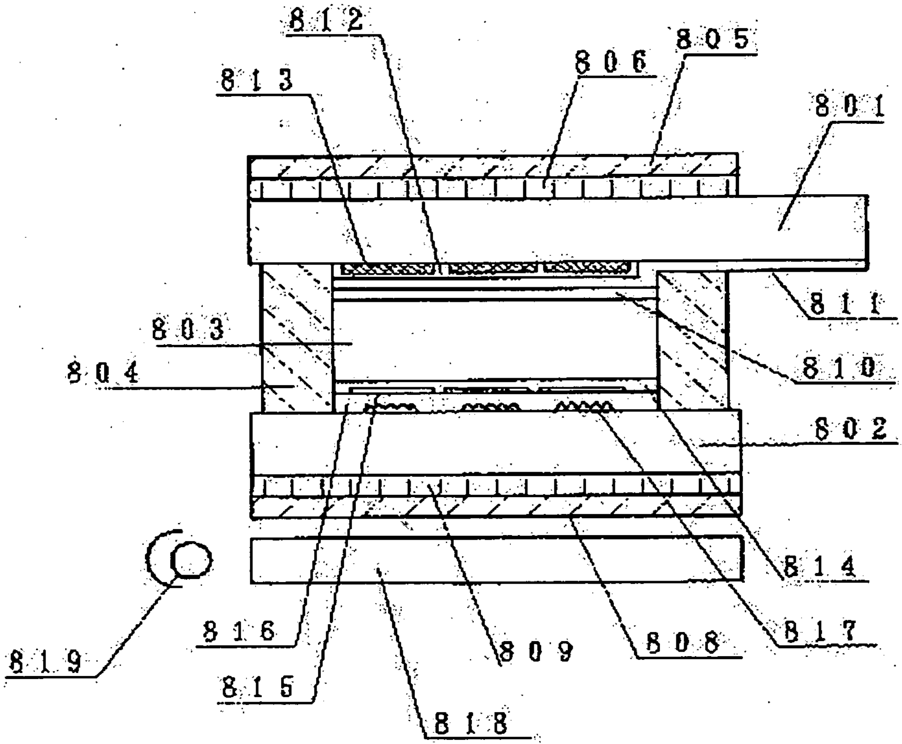
【FIG. 8】



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【FIG. 9】

(a)

(b)

(c)